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Effect of Curvature on the Conformal Microstrip Antenna

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Abstract

A comprehensive study of the conformal microstrip printed antenna is presented. The main advantages and drawbacks of a microstrip conformal antenna are discussed. The paper discusses both conformal microstrip arrays. The effect of curvature on the conformal Microstrip antenna patch on conical and spherical surfaces is studied. New flexible antenna designs are given for different frequencies. Finally, simulation studies are carried out to study the effect of the curvature on the input impedance, return loss, voltage standing wave ratio, and resonance frequency.

Introduction

Conformal microstrip antennas are very important in many applications such as mobile communications, airplanes, rockets, radar and satellites . Conformal antennas are mainly the following advantages over the planer microstrip antennas :

1. Conformal antennas have little effect of carrier's own aerodynamic properties due to its conformal surface.
2. Conformal antennas can be used to simplify the antenna installation under the conditions of assuring the performance of the antenna.
3. Conformal antennas can eliminate or reduce the error caused by radome.
4. Cylindrical conformal antennas give nearly Omni-directional radiation pattern.
5. Conformal antennas have large angle coverage.

Due to the several advantages of conformal antennas, it is very popular in the different flight aircrafts. On the other side, a conformal microstrip antenna has some drawbacks due to bedding, those drawbacks are summarized below:

1.The dielectric material will undergo stretching and compression along the inner and outer surfaces, respectively.
2. Shaping the material can also result in a change in both the dielectric constant and material thickness.
3.Dielectric materials will suffer from cracking due to bending and that will affect the performance of the conformal microstrip antenna.

Cylindrical-Rectangular Patch Antenna

Cylindrical-rectangular patch is the most famous and popular conformal antenna. Manufacturing of this antenna is very easy with respect to spherical and conical antenna especially in the military field. Research in this type of conformal antenna started in the early eighties .

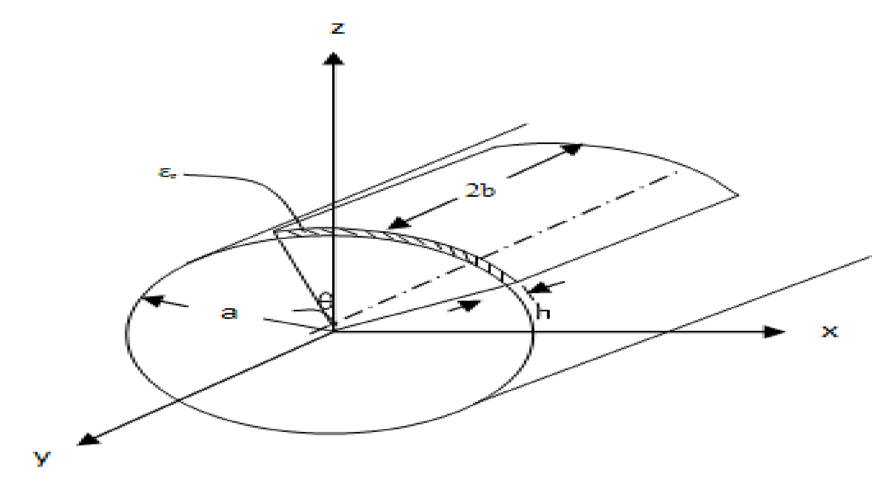

Fig1: Geometry of cylindrical-rectangular patch antenna

Krowne calculated the resonance frequency for a cylindrical-rectangular patch and he carried a comparison with planar rectangular patch antenna. The field distribution within the antenna has been determined using a cavity model for TE_{mn} (transverse electric) and TM_{mn} (transverse magnetic), where m and n are the modes of operations and indicated that only discrete solutions for the transverse TM and TE.
The resonance frequency is given by :

$$(f_r)_{mn} = \frac{1}{2\sqrt{\mu\varepsilon}} \sqrt{\left(\frac{m}{\theta a}\right)^2 + \left(\frac{n}{2b}\right)^2} \qquad (1)$$

Where 2b is a length of the patch antenna, a is a radius of the cylinder, θ is the angle bounded the width of the patch, ε represents electric permittivity and µ is the magnetic permeability as shown in figure 1

Results

We introduce some simulation results, using FEKO software . The effect of radius of curvature on performance of microstrip antenna is studied. For a flat microstrip printed antenna resonate at 2.25 GHz and input impedance is around 52 Ω, the effect of curvature on its shape is shown in figure 2. For 50 mm, 45 mm, 40 mm, 35 mm, and 30 mm radius of curvature (R), the input impedance (Z) is changed with R as in Figure 3 and summarized in Table 1. The voltage standing wave ration (VSWR) and the return loss (S11) are also studied in figures 4 and 5 respectively. The dimensions of the patch are 41.5 mm length and 50.2 mm width, while the dimensions of the ground plat are 83 mm length and 100.4 mm width, and the position of the patch is centered on the ground plat as shown in Figure 2.a. The feeding position is 8.25 mm from the center of the patch and along the length of the patch. The dielectric material is Teflon with dielectric constant 2.1 and thickness 2 mm.

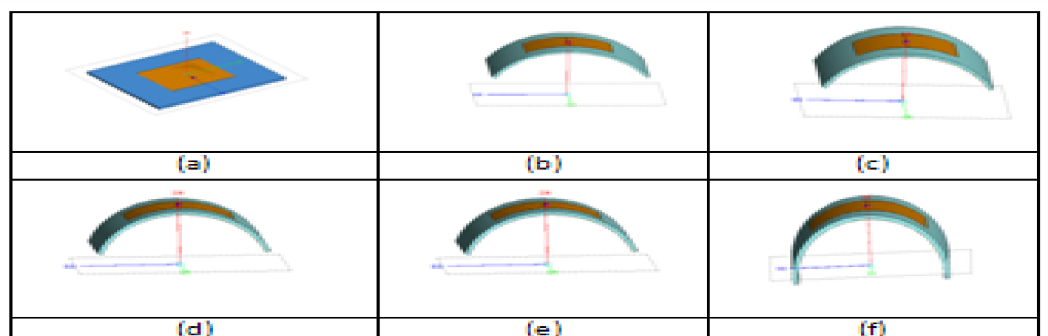

Figure 2 different radius of curvatures (R) for the same antenna
a) Flat antenna; b) R = 50 mm; c) R = 45 mm
d) R = 40 mm; e) R = 35 mm; f) R = 30 mm

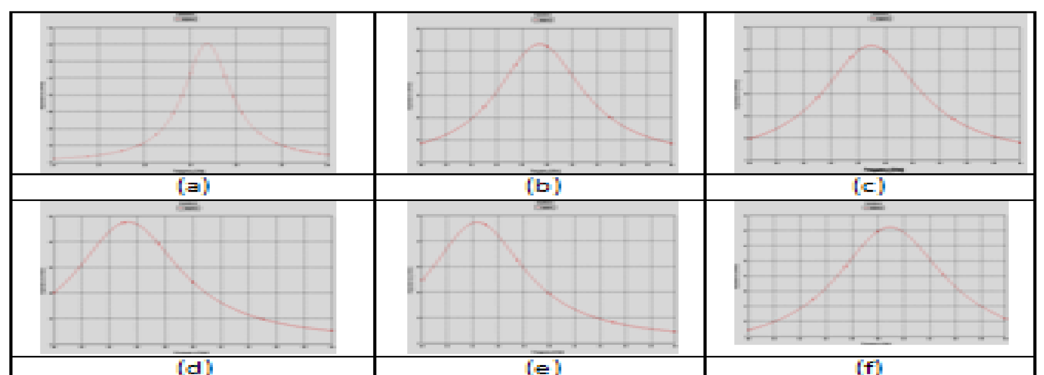

Figure 3 input impedance (Ω) as a function of frequency (GHz)
a) Flat antenna; b) R = 50 mm; c) R = 45 mm
d) R = 40 mm; e) R = 35 mm; f) R = 30 mm

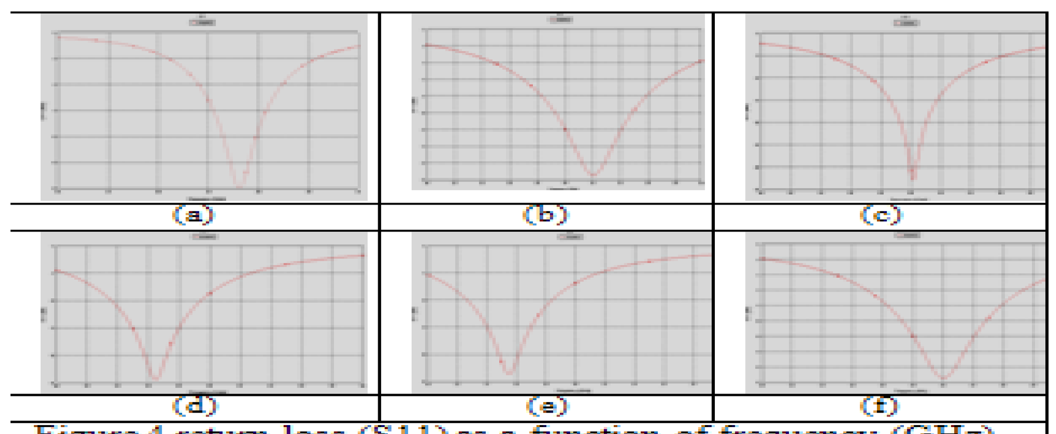

Figure 4 return loss (S11) as a function of frequency (GHz)
a) Flat antenna; b) R = 50 mm; c) R = 45 mm
d) R = 40 mm; e) R = 35 mm; f) R = 30 mm

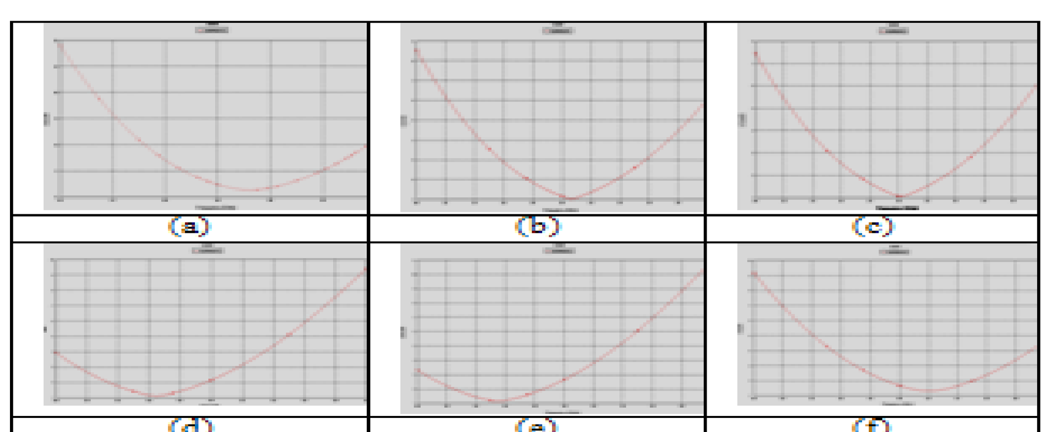

Figure 5 VSWR as a function of frequency (GHz)
a) Flat antenna; b) R = 50 mm; c) R = 45 mm
d) R = 40 mm; e) R = 35 mm; f) R = 30 mm

The result for the radius of curvature R (mm) as a function of resonance frequency fr (GHz) and input impedance Z (ohm) are shown in Table 1.

Table 1, R as a function f_r and Z

R (mm)	f_r (GHz)	Z (Ω)
Flat (infinity)	2.25	50
50	2.23	52.9
45	2.29	51.7
40	2.24	47.7
35	2.23	47.2
30	2.3	41.2

CONCLUSION

The effect of curvature on the performance on a microstrip printed is discussed. For cylindrical microstrip printed antenna, we presented reported studies about calculation of the input impedance, resonance frequency, the voltage standing wave ratio of that antenna. We studied the radius of curvature effect on the input impedance, return loss, and VSWR. The resonance frequency is minimally affected and can be neglected. It can be fairly assumed that the resonance frequency is constant with curvature.